CLAIMS

What is claimed is:

1. A process for treating a waste material comprising:

(a) introducing the waste material into a vessel;

(b) heating and pulverizing the waste material under conditions effective to produce materials comprising waste powder and drum gas wherein the drum gas comprises volatile hydrocarbon components and water;

(c) recovering the drum gas from the vessel;

(d) subjecting the waste powder to a first plasma arc wherein the waste powder is converted to molten materials and synthesis gas;

(e) recovering the synthesis gas of step (d); and

(f) recovering the molten material of step (d).

2. The process according to claim 1 further comprising:

(g) using the synthesis gas of step (e) as a heat source for the vessel of step (a).

3. The process according to claim 1 wherein the vessel is a rotatable drum.

4. The process according to claim 1 further comprising:

(g) condensing the drum gas from step (c).

5. The process according to claim 4 further comprising:

(h) recovering any uncondensed gas from step (g).

6. The process according to claim 1 further comprising:

(g) subjecting the drum gas from step (c) to a second plasma arc wherein the drum gas is converted to materials comprising molten material, synthesis gas or both.

7. The process according to claim 6 wherein the synthesis gas produced in step (g) is used as the heat source for the vessel of step (a).

8. The process according to claim 1 wherein the heating in step (b) is carried out by passing the synthesis gas around the outside of the vessel of step (a).

9. The process according to claim 1 wherein the heating in step (b) is carried out by passing the synthesis gas into the vessel of step (a) wherein the synthesis gas mixes with the drum gas to form a combined gas mixture.

10. The process according to claim 9 further comprising:

(g) separating the synthesis gas from the combined gas mixture to produce a second synthesis gas stream.

11. The process according to claim 10 wherein the second synthesis gas stream is produced by condensing at least a portion of the drum gas from the combined gas mixture.

12. The process according to claim 9 further comprising:

(i) subjecting the combined gas stream to a second plasma arc wherein the combined gas stream is converted to materials comprising molten material, synthesis gas or both.

13. An apparatus for processing a waste product comprising:

a rotatable drum having an inlet end and an outlet end with said inlet end attached to an inlet bulkhead by a first seal and said outlet end attached to an outlet bulkhead by a second seal; said drum configured such that a material placed in said drum via an opening in said inlet bulkhead flows from said drum via an outlet opening in said outlet bulkhead; and wherein said seals separate the inside of said drum from the outside; and

an enclosure disposed about said drum having an inlet end with an enclosure inlet opening and an outlet end with an enclosure outlet opening for circulating hot gas over the outside of said drum to heat the material in said drum;

a plasma reactor connected to said drum outlet bulkhead opening for receiving and processing said waste material from said drum; said reactor having a gas removal opening connected to said drum enclosure inlet opening for removing the gas created by said reactor, and at least one other opening for removing molten material from said reactor; and

a recirculation blower, having a blower inlet connected to said drum enclosure outlet opening and a blower outlet connected to said gas removal opening of said plasma reactor for blending said created reactor gas with the gas circulated around said drum.

14. The apparatus of Claim 13 including a cyclone connected to said gas removal opening to remove solids from said created gas.

15. The apparatus of Claim 13 including a venturi exhauster having a driving fluid inlet connected to said blower outlet, a feed inlet connected to said gas removal opening and an exhauster outlet connected to said enclosure inlet to assist in drawing said reactor gas from said reactor and blending said reactor gas with said circulated gas.

16. The apparatus of Claim 13 including a controllable source of cooling and/or reforming medium suitably connected to said reactor.

17. An apparatus for processing a waste product comprising:

a rotatable drum having an inlet end and an outlet end with said inlet end attached to an inlet bulkhead by a first seal and said outlet end attached to an outlet bulkhead by a second seal; said inlet bulkhead having a waste inlet opening for flowing said waste product to the inside of said drum and a vapor outlet opening for removing gas from said drum, and said outlet bulkhead having a solids outlet opening for removing the solid material in said drum and a hot gas inlet opening for receiving a hot gas; said drum being configured such that the solid waste material flowing through said waste inlet opening flows from the inlet end of said drum to said solids outlet opening and such that hot gas flowing through said hot gas inlet opening flows through said drum to heat said waste in said drum, and flows out said gas outlet opening; said seals separating the inside of said drum from the outside;

a plasma reactor connected to said solids outlet opening for receiving and processing said solid material from said drum; said reactor having a gas removal opening connected to said hot gas inlet opening for removing the gas created by said reactor, and at least one other opening for removing the molten material from said reactor;

a conduit connected to said vapor outlet opening in said inlet bulkhead for receiving said hot gas from said reactor and the vapors created from said waste and conducting them out of said drum.

18. The apparatus of Claim 17 wherein the outlet of said conduit flows through a venturi scrubber connected to said conduit for scrubbing said hot gas and vapors, and wherein the outlet of said scrubber is connected to a container for collecting the liquids and gasses from said scrubber, and wherein a pump is connected to said container for removing and recirculating liquids in said container to a driving fluid inlet in said Venturi scrubber.

19. The apparatus of Claim 17 including a controllable source of cooling and/or reforming medium suitably connected to said reactor.

20. The apparatus of Claim 18 including an air cooler connected between the outlet of said pump and said Venturi scrubber for cooling said re-circulated liquid.

21. The apparatus of Claim 19 including a demister element in said container for removing free liquid droplets from said gasses.

22. The apparatus Claim 19 including a controllable stream outlet in said container, connected to a centrifuge, for removing a side stream of said liquid and separating said side stream into solids, oil and water; said centrifuge having a controllable water line connected to said container for maintaining a desired level in said container.

23. The apparatus of Claim 17 including means to supply additional external heat to said drum.

24. An apparatus for processing a waste product comprising:

a rotatable drum having an inlet end and an outlet end with said inlet end attached to an inlet bulkhead by a first seal and said outlet end attached to an outlet bulkhead by a second seal; said inlet bulkhead having a waste inlet opening for flowing said waste product to the inside of said drum and a gas outlet opening for removing gas from said drum, and said outlet bulkhead having a solids outlet opening for removing the solid material in said drum and a hot gas inlet opening for receiving a hot gas; said drum being configured such that the solid waste material flowing through said waste inlet opening flows from the inlet end of said drum to said solids outlet opening and hot gas flowing through said hot gas inlet opening flows through said drum to heat said waste in said drum and flows out said gas outlet opening in said inlet bulkhead; said seals separating the inside of said drum from the outside;

a first plasma reactor connected to said solids outlet opening for receiving and processing said solid material from said drum; said reactor having a first gas removal opening connected to said hot gas inlet opening of said drum outlet bulkhead for removing the gas created by said first reactor, and at least one other opening for removing the molten material from said first reactor;

a second plasma reactor, having a first conduit connected to said gas outlet opening of said inlet bulkhead, for receiving and processing said gasses from said outlet opening; said second reactor having a second gas removal opening and at least one other opening for removing the molten material from said second reactor;

a second conduit, connected to said second reactor gas outlet opening for receiving said hot gas from said reactor.

25. The apparatus of Claim 24 wherein said second conduit includes a cyclone for removing solids in the hot gas flowing through said conduit.

26. The apparatus of Claim 24 including a controllable source of cooling and/or reforming medium suitably connected to said first and second reactors.

27. The apparatus of Claim 24 including a cross exchanger positioned in said first and second conduit to heat said drum gas from said drum and cool said hot gas from said cyclone.

28. An apparatus for processing a waste product comprising:

a rotatable drum having an inlet end and an outlet end with said inlet end attached to an inlet bulkhead by a first seal and said outlet end attached to an outlet bulkhead by a second seal; said drum configured such that a material placed through an opening in said inlet bulkhead flows from the inlet through a solids outlet opening in said outlet bulkhead and the vapors and gasses created in said drum flow out a gas outlet opening in said inlet bulkhead; said seals separating the inside of said drum from the outside;

an enclosure disposed about said drum having an inlet end with an enclosure inlet opening and an outlet end with an enclosure outlet opening for circulating hot gas over the outside of said drum to heat the material in said drum;

a plasma reactor connected to said solids outlet opening for receiving and processing the solid waste material from said drum; said reactor having a gas removal opening connected to said drum enclosure inlet opening for removing the reactor gas created by said reactor, and at least one other opening for removing molten material from said reactor;

a recirculation blower having a blower inlet connected to said drum enclosure outlet opening and a blower outlet connected to said gas removal opening of said reactor for blending said created gas with the gas circulated around said drum; and a first conduit connected between said blower and said drum enclosure for selectively removing said circulated gas from said apparatus;

a second conduit connected to said gas outlet opening in said inlet bulkhead for collecting said vapors and gasses from in said drum.

29. The apparatus of Claim 28 including a cyclone suitably positioned in the line of said reactor gas removal opening to remove solids in said reactor gas.

30. The apparatus of Claim 29 including a venturi exhauster having a driving fluid inlet connected to said blower outlet, a feed inlet connected to the outlet of said cyclone and an exhauster outlet connected to said enclosure inlet.

31. The apparatus of Claim 28 including a controllable source of cooling and/or reforming medium suitably connected to said reactor.

32. The apparatus of Claim 28 including a venturi scrubber connected to said conduit, for scrubbing said hot gas and vapors, having a container connected to the outlet of said scrubber, for collecting the liquids and gasses from said scrubber, and a pump, connected to said container, for removing and recirculating said container liquid to a driving fluid inlet in said Venturi scrubber; said container having a gas outlet for removing the gasses collected in said container.

33. The apparatus of Claim 31 including a demister element in said gas outlet of said container for removing free liquid droplets from said gasses.

34. The apparatus of Claim 31 including an air cooler connected between the outlet of said pump and said Venturi scrubber for cooling said re-circulated liquid.

35. The apparatus of Claim 31 including a controllable liquid outlet in said container for selectively removing the liquid collected in said container.

36. The apparatus of Claim 31 including a controllable liquid supply line for maintaining a selected liquid level in said container.

37. An apparatus for processing a waste product comprising:

a rotatable drum having an inlet end and an outlet end with said inlet end attached to an inlet bulkhead by a first seal and said outlet end attached to an outlet bulkhead by a second seal; said drum configured such that a material placed in said drum via an opening in said inlet bulkhead flows from said drum via a solids outlet opening in said outlet bulkhead and the drum gasses

created in said drum flow out of said drum via a gas outlet opening in said inlet bulkhead; said seals separating the inside of said drum from the outside;

an enclosure disposed about said drum having an inlet end with an enclosure inlet opening and an outlet end with an enclosure outlet opening for circulating hot gas over the outside of said drum to heat the material in said drum;

a first plasma reactor connected to said solids outlet opening for receiving and processing the solid waste material from said drum; said reactor having at least a first opening for removing molten material from said reactor; and having a second opening connected to a first conduit for removing the reactor gas created by said first reactor;

a second plasma reactor having a second conduit connected to said gas outlet opening for receiving and processing said drum gasses from said drum; said second reactor having a third gas removal opening connected by a third conduit to said enclosure inlet opening for removing the hot gas created by said second reactor, and having at least a fourth opening for removing the molten material from said second reactor;

a recirculation blower, having a blower inlet connected to said drum enclosure outlet opening and a blower outlet connected to said third conduit for blending gas created in said second reactor with the gas circulated over said drum;

a fourth conduit connected between said blower and said drum enclosure for selectively removing said circulated gas from said apparatus.

38. The apparatus of Claim 37 including a cyclone positioned in said first conduit to remove solids from said reactor gas.

39. The apparatus of Claim 37 including a cyclone positioned in said third conduit to remove solids from said second reactor gas.

40. The apparatus of Claim 38 including a venturi exhauster having a driving fluid inlet connected to said blower outlet, a feed inlet connected to the outlet of said cyclone, and an exhauster outlet connected to said drum enclosure inlet.

41. The apparatus Claim 37 including a controllable source of cooling and/or reforming medium suitably connected to said first and second reactors.

42. The apparatus Claim 37 including a cross exchanger positioned in said first and second conduits to heat said drum gas from said drum and cool said first reactor gas.

43. The process of processing a waste material and producing a gas from said waste material including the steps of:

preparing a plasma reactor feed by preheating and pulverizing said waste material in a heated rotating drum;

processing said prepared feed with a plasma reactor;

removing gas created by said plasma reactor from said plasma reactor and circulating it over the outside of said rotating drum to cool said gas and heat said drum.

44. The process of processing a waste material and producing a gas from said waste material including the steps of:

preparing a plasma reactor feed by preheating and pulverizing said waste material in a rotating drum;

processing said prepared feed with a plasma reactor;

removing gas created by said plasma reactor from said plasma reactor and flowing it through the inside of said drum to preheat said waste material and to vaporize the water and light hydrocarbons in said feed;

removing the gas and water and hydrocarbons vapors from the drum;

condensing the water and condensable hydrocarbons from the drum gas and vapors to furnish a stream of gas.

45. The process of processing a waste material and producing a gas from said waste material including the steps of:

preparing a plasma reactor feed by preheating and pulverizing said waste material in a heated rotating drum;

processing said prepared feed with a first plasma reactor;

removing gas created by said first plasma reactor from said first plasma reactor and flowing it through the inside of said drum to preheat said waste material and to vaporize the water and light hydrocarbons in said feed;

removing the gas and water and hydrocarbons vapors from the drum;

processing said gas and vapors removed from said drum with a second plasma reactor.

46. The process of processing a waste material and producing a gas from said waste material including the steps of:

preparing a plasma reactor feed by preheating and pulverizing said waste material in a heated rotating drum;

processing said prepared feed with a plasma reactor;

removing gas created by said plasma reactor from said plasma reactor and circulating it over the outside of said drum to cool said gas and heat said drum, and to supply a stream of cooled gas;

removing the water and hydrocarbon vapor from said drum and cooling said vapors to condense said water and the condensable hydrocarbon vapors to supply a stream of other gas.

47. The process of processing a waste material and producing a gas from said waste material including the steps of:

preparing a plasma reactor feed by preheating and pulverizing said waste material in a heated rotating drum;

processing said prepared feed with a first plasma reactor;

removing gas created by said first plasma reactor from said first plasma reactor to supply a first gas stream;

processing with a second plasma reactor the gas and vapors created in said heated drum and removed from said drum;

removing gas created by said second plasma reactor from said second plasma reactor and circulating it over said drum to heat said drum and to supply a second gas stream.